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# Proceedings

## 2000 STAR Regional Scale Analysis and Assessment Progress Review Workshop

### September 18-19, 2000
### Las Vegas, Nevada

NATIONAL CENTER FOR ENVIRONMENTAL RESEARCH

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# Introduction

The mission of the United States Environmental Protection Agency (EPA) is to protect public health and safeguard and improve the natural environment—the air, water, and land upon which life depends. Achievement of this mission requires the application of sound science to the assessment of environmental problems and to the evaluation of possible solutions. The National Center for Environmental Research (NCER) at EPA is committed to providing the best products in high-priority areas of scientific research through significant support for long-term research.

The Office of Research and Development's (ORD) Environmental Monitoring and Assessment Program (EMAP) identifies integrating information across multiple scales as one of its largest challenges. This approach is based on The Committee on Environment and Natural Resource's (CENR) publication entitled *Integrating the Nation's Environmental Monitoring and Research Networks and Programs*, *A Proposed Framework*.

In support of this identified research need, NCER issued a Request for Applications (RFA) on Regional Scale Analysis and Assessment in 1997. It was followed up with subsequent RFAs in 1998 and 1999. The purpose of these solicitations was to support research that would lead to the development and demonstration of approaches to link site-specific information with regional survey data and remote sensing imagery for conducting regional-level ecological assessments. A total of 11 grants have been funded under this program. This research represents part of the extramural component of ORD's Environmental Monitoring and Assessment Program (EMAP). You may find extensive information about the EMAP Program at http://www.epa.gov/EMAP.

Annual program reviews such as this allow investigators to interact with one another and discuss progress and findings with EPA and other interested parties. If you have any questions regarding the program, please contact the Program Manager, Barbara Levinson, by telephone at 202-564-6911, or by e-mail at levinson.barbara@epa.gov.

# Section 1.

## Projects Initiated With Fiscal Year 1997 Support

# Assessment of Forest Disturbance in the Mid-Atlantic Region: A Multiscale Linkage Between Terrestrial and Aquatic Ecosystems

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The objective of this project is to develop, test, validate, and demonstrate an analytical framework for assessing regional-scale forest disturbance in the Mid-Atlantic region by establishing a multiscale linkage between forest disturbance and forest nitrogen export to surface waters. It is hypothesized that excessive nitrogen (N) leakage (export) from forested watersheds is a potentially useful, integrative "indicator" of a negative change in forest function that occurs in synchrony with changes in forest structure and species composition. This research project focuses on forest disturbance associated with historical defoliations by the gypsy moth larva at spatial scales ranging from small watersheds to the entire region.

The technical approach for establishing a multiscale linkage between forest disturbance (i.e., gypsy moth defoliation) and N leakage to surface waters has made use of extensive forest, forest disturbance, and water quality data collected for the Mid-Atlantic region at all spatial scales (intensive watershed sites, subregional survey, regional survey, and remotely sensed data). These data were supplemented with on-the-ground measurements of forest species composition for a selected sample of watersheds for which N export had been previously monitored.

In early 2000, an analysis was completed of regional-scale forest disturbance and associated dissolved N export from Shenandoah National Park (SNP), Virginia—a large contiguous area of forested land within the Chesapeake Bay Watershed. Long-term watershed research conducted in SNP indicates that annual export of dissolved N from forested watersheds to surface waters increases dramatically in response to vegetation disturbances. These results suggest that a parsimonious, empirical unit N export response function (UNERF) model can explain large percentages of the temporal variation in annual N export from a group of small gaged forested watersheds in the years following disturbance. The empirical UNERF modeling approach is completely analogous to the unit hydrograph technique for describing storm runoff, with the model representing annual N export as a linear deterministic process both in space and time.

The purposes of this analysis were to: (1) test the applicability of the UNERF model using quarterly streamwater nitrate data from a group of ungaged watersheds in SNP; (2) demonstrate a park-wide application of a regional UNERF model that references the geographic distributions of bedrock geology and the timing of gypsy moth defoliation over the entire SNP area; and (3) visualize the temporal and spatial patterns in vegetation disturbance and annual dissolved N export through the use of PC-based animation software.

The results of this analysis showed that: (1) forested ecosystems within SNP normally retain a very high percentage of atmospherically deposited N, but forest disturbances such as insect defoliation can dramatically alter the input/output balance; (2) annual nitrogen export from SNP forests began increasing in 1987 from a baseline rate of about 0.1 kg/ha, peaked in 1992 at an average rate of 1.68 kg/ha (more than a 1,500% increase), and has since been steadily declining (see Figure 1); (3) natural biogeochemical processes need to be considered in modeling N export dynamics of forests; and (4) linear systems models can apparently provide parsimonious approximations of ecosystem complexity that are useful for purposes of regionalization.

In the final year of the research project, this type of integrative analysis will be extended to other forested watersheds in the Chesapeake Bay Watershed. The focus will be on first through third order drainages in the Mid-Atlantic Highlands Area (MAHA) that comprise a target subpopulation of the EMAP surface water survey in the eastern United States. In completing this analysis, historical remote-sensing data (AVHRR) will be used as a means of better characterizing the spatial and temporal variations in forest defoliation within the region during the last 15 years.

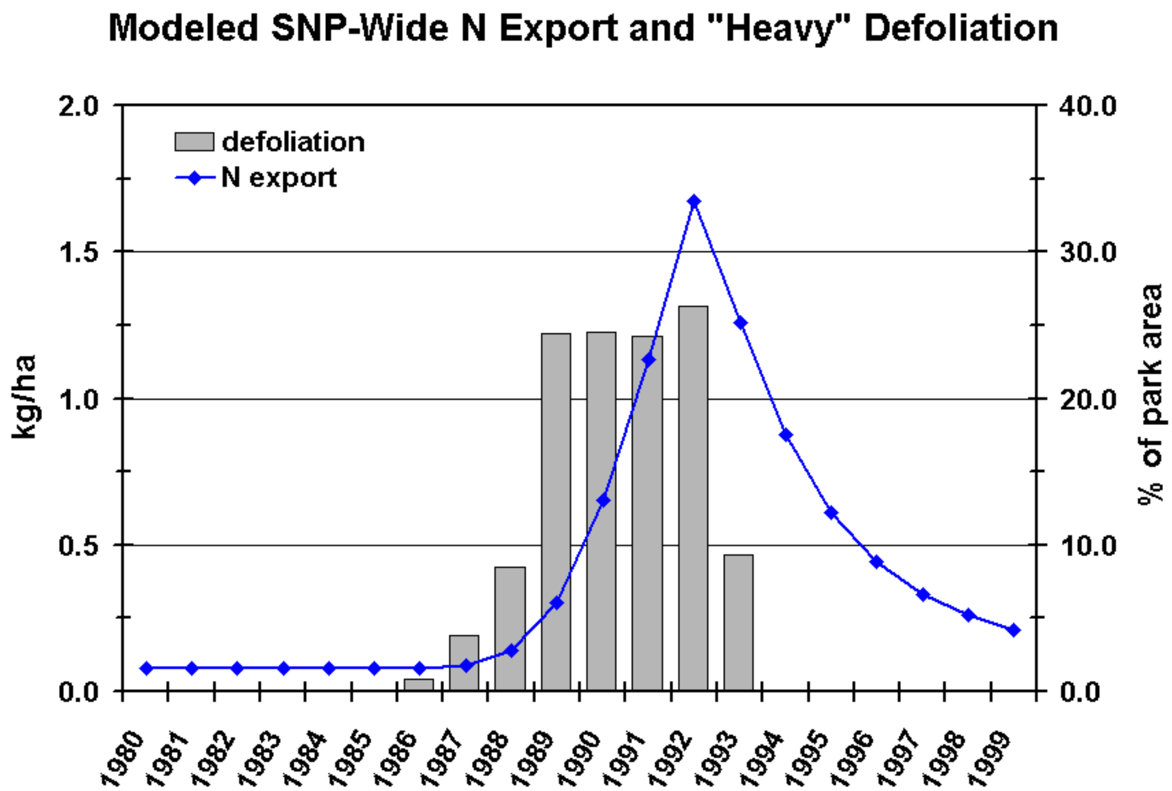


**Figure 1.** Modeled SNP-wide N export to surface waters and heavy gypsy moth defoliation during the period 1980-1999.

# Section 2.

## Projects Initiated With Fiscal Year 1998 Support

# Multilevel Statistical Modeling for Generalizing From Case Studies

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Case studies, the foundation of environmental reearch, are too often faced with a very difficult "so what?" criticism. Just because certain findings apply to a given study site does not necessarily mean that they apply to any others. Yet, the goal of such research commonly is to arrive at broadly relevant conclusions.

In this research project, a generalization of multilevel statistical modeling is employed to consider the degree to which credible conclusions across a set of case study sites can be drawn. Multilevel modeling within a regression analysis framework allows for the explicit consideration of how statistical summaries vary systematically over a set of sites. As a result, the degree to which findings can be applied beyond a single site is addressed directly.

The contribution of this research project is to provide a generalization of multilevel modeling and the necessary software, so that the generalized linear model can be worked with, including such features as spatial and temporal dependence, inherently nonlinear relationships, and latent variables. For example, outcomes can be categorical, and sites closer to one another in space may be treated systematically as more alike. The emphasis in this research project is on technique, with the data used as an illustration. The data come from a Regional Environmental and Monitoring Assessment Program (R-EMAP) project, U.S. Environmental Protection Agency Region 9, undertaken in conjunction with the Environmental Science and Engineering Program at the University of California at Los Angeles. The research involves a spatially intensive stream bioassessment monitoring study for Calleguas Creek Watershed, Ventura County, CA.

This project includes sampling of riparian habitat and streams for two seasons between 1999 and 2000. Data are collected at 70 sites. Field assessment in the watershed includes water quality, physical habitat assessments (e.g., measures and/or visual estimates of channel cross-sectional dimensions, substrate, fish cover, bank characteristics, and riparian vegetation structure), and benthic and fish community sampling. The project seeks to assess the current ecological condition of coastal Southern California streams and examine impacts of land use on water quality and aquatic ecosystem integrity.

# Regional Scale Impacts of Phase I of the Clean Air Act Amendments: The Relation Between Emissions and Concentrations, Both Wet and Dry

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A comparison of data records in the 1990s both before (1991–94) and after (1995–97) implementation of Phase I of the Clean Air Act Amendments (CAAA) of 1990 for seven regions of the eastern United States shows a significant reduction in $SO_2$ emissions for most states, except for Texas, North Carolina, Illinois, Florida, and Alabama. However, of the major $NO_X$ emitting states, only two eastern states (New York and Pennsylvania) show significant declines in $NO_X$.

A pattern of large declines in $SO_2$ emissions ( > 20%) after CAAA implementation, and large declines in precipitation concentrations of $SO_4^=$ and $H^+$, as well as air concentrations of $SO_2$ and $SO_4^=$ (components of dry deposition) exists for most regions of the eastern United States. The regions examined include: Northern New England and the Adirondack Mountains (NE); New York, excluding the Adirondack Mountains (NY); Pennsylvania, northern West Virginia and eastern Ohio (PA); Delaware, Maryland, and eastern Virginia (M-A); Ohio, eastern Indiana, and northern Kentucky (OH); Illinois and western Indiana (IL); and the southern Appalachian Mountains and surrounding area (SA). In most cases, the emission/concentration relations are close to 1:1 (a near equal percent decline in concentrations for a given percent decline in emissions) when the source region based on 15-hour air mass back trajectories is used for the New England region, and source regions based on 9-hour back trajectories are used for the other eastern regions.

The southern Appalachian Mountain region is an acid-sensitive area receiving high levels of acidic deposition that has not seen an appreciable improvement in precipitation acidity. This area also has had the least improvement in wet and dry sulfur concentrations of the areas examined (see Table 1). Precipitation base cations ($Ca^{++}$ and $Mg^{++}$) show a pattern of increasing or level concentrations when comparing 1990–1994 to 1995–1998 data for six of the seven regions that were examined. Ammonium concentrations generally have changed less than 10 percent, except for the Illinois region and the southern Appalachian Mountain region, both of which increased more than 15 percent.

A future focus of this work will include an evaluation of how changing emission levels will affect New England waters, using the Hubbard Brook Experimental Forest as a test case.

**Table 1.** Changes in emissions of: (a) $NO_X$, (b) $SO_2$, and (c) combined emissions from source regions based on 9-hour back trajectories (except for NE, which is based on 15-hour back trajectories), expressed as percentagess; and changes, also expressed as percentages, in: (d) precipitation $SO_4^=$ concentrations, (e) $SO_2$ and particulate $SO_4^=$ air concentrations (sources of dry S deposition), and (f) precipitation acidity ($H^+$ concentrations) for the study regions. The years 1991–1994 (pre-CAAA implementation) are compared with 1995–1997 (post-CAAA implementation). The percentage change in parentheses for NE and under (b) represent changes in emissions when the Province of Ontario is included as part of the source region.

| | EMISSIONS | | | CONCENTRATIONS | | |
|---|---|---|---|---|---|---|
| **91-94 vs. 95-97** | **(a) $NO_x$ % change** | **(b) $SO_2$ % change** | **(c) 2S + N (moles) % change** | **(d) $SO_4^=$ wet % change** | **(e) S dry % change** | **(f) $H^+$ wet % change** |
| **NE** | -10 | -20 (-19) | -17 | -25 | -29 | -14 |
| **NY** | -12 | -24 (-22) | -20 | -24 | -23 | -22 |
| **PA** | -7 | -23 | -18 | -21 | -21 | -17 |
| **M-A** | -3 | -22 | -15 | -24 | -18 | -19 |
| **OH** | +2 | -23 | -16 | -18 | -23 | -16 |
| **IL** | +2 | -20 | -13 | -12 | -20 | -17 |
| **SA** | +5 | -19 | -11 | -6 | -10 | < -1 |

# Regional Analysis of Variation in Adirondack Lake Ecosystems: Landscape Scale Determinants of Dissolved Organic Carbon

***Michael L. Pace, Charles D. Canham, and Michael Papaik***
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Lakes represent a critical ecological and economic resource. The consequences of many types of air and water pollution have been manifested and best understood in the study of lakes, especially at regional scales, as for example in studies of the consequences of eutrophication and acidification.

The goal of this research project is to develop an approach to assessing variation in lake-watershed interactions at a regional scale. Specifically, it is sought to predict variation in lake ecosystem properties as a function of landscape characteristics, especially in relation to landscape and within lake processes that determine variation in lake dissolved organic carbon (DOC).

Lake DOC is an important measure of overall lake conditions and is one of the primary features that varies among lakes in landscapes where lakes are not heavily impacted by nutrient loading. The focus of this study is on the Adirondack Park of New York State. This region represents one of the largest areas of wilderness and minimally developed land in the United States east of the Mississippi River. Because of extensive prior studies, there are large numbers of data sets on the watersheds and lakes of the Adirondacks.

From this information, data on the water chemistry and complementary watershed data have been assembled for more than 600 lakes in the Oswegatchie Black and Upper Hudson Watersheds of the Park. This data set is a representative sample of the larger number of lakes in the region. Data layers allow for visualization of the elevation contours (from a new digital elevation map with 10 m resolution); all standing water bodies; uplands in five categories of land use; wetlands in eight categories derived from a more extensive classification of wetland type; the extent of wetlands that fringe lakes at 50 m, 100 m, and 200 m intervals; streams; watershed boundaries; roads; and developed areas. A complete chemistry data set for the study lakes has been assembled from earlier water quality studies conducted by the Adirondack Lake Survey. A series of watershed statistics have been added to this data set using Geographic Information System (GIS) analysis.

Two analytical projects currently are underway. The first is a multivariate statistical analysis of watershed and lake characteristics with a goal of empirically evaluating controls on the variation in DOC observed among lakes at a regional scale.

The second analysis is the development of a maximum likelihood mass balance model for lake DOC. This model will describe the inputs, outputs, and within-system processing of DOC in lakes. A key feature of this model is the spatial analysis of inputs of DOC along flow paths to a lake from various landscape source areas. Flowpath data sets have been developed in the initial GIS analysis of the watersheds to parameterize these input functions. A simulated annealing algorithm will be used to iteratively solve the basic model equation describing inputs, processing, and outputs. This approach will solve simultaneously for the parameter values that maximize the likelihood of the data set where mean lake DOC is predicted.

# Methodologies for Extrapolating From Local to Regional Ecosystem Scales: Scaling Functions and Thresholds in Animal Responses to Landscape Pattern and Land Use

***John A. Wiens and Beatrice Van Horne***
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The objective of this research project is to develop and test new concepts and methods for evaluating how the structure and configuration of landscapes change with changes in spatial scale, and how these changes in landscape scale relate to the scales at which various groups of plants and animals respond to the environment, which ultimately affects their distribution and abundance.

Specifically, the aims of this project are to: (1) develop ways of modeling how the scaling of species' responses to environmental variation is coupled to scale-dependent changes in landscape composition and structure; (2) develop protocols for determining the scales at which the responses of species and communities are likely to exhibit thresholds, based on functional properties of the species; and (3) develop mathematical scaling functions that can be coupled with Geographic Information Systems (GISs) to make use of remote sensing. The overall goal is to derive scaling functions and GIS-based spatial models that can be used to assess how information gathered at fine scales in intensive studies can be extrapolated to the broad scales of ecological monitoring and environmental risk assessment.

There are three phases to this research. The first phase is using existing data sets (faunal surveys, GIS layers, remote sensing) to explore how to link the spatial structure of landscapes with the distribution of organisms over multiple scales, and to determine the most appropriate statistical approaches to such scaling relationships. The second phase is gathering information on the spatial configuration of landscapes and the distribution of key groups of organisms (vascular plants, beetles, butterflies, and birds) at five study sites located on a broad-scale gradient from the shortgrass steppe to the tallgrass prairie (see Figure 1). This series spans a gradient of increasing precipitation, productivity, and land-use intensity, and will provide the foundation for detailed multiscale analyses. The third phase is using the data to derive and test mathematical, GIS, and spatial models that relate changes in species occurrences, functional group composition, and biodiversity at multiple scales to the scaling properties of landscapes.

Data sets have been used for grasshopper distributions in eastern Wyoming and bird and vegetation distributions in Idaho shrub steppe to explore several approaches to the analysis of spatially referenced data. These studies have evaluated: (1) the differences between using land-cover classification data and quantified or ordinal data in multivariate ordinations in GIS-based analyses of the environmental correlations of animal distributions; and (2) ways of determining the contributions of geographical distance to assessments of community-environment relationships. The studies in phases two and three are just beginning.

These studies show that multivariate ordinations may reveal features of environmental associations of organisms that are not apparent when using classified (categorical) data, and that geostatistical modeling can considerably improve the explanatory power of causal models of variations in community composition.

Detailed information on the spatial properties of landscapes and organism distributions at scales from 1 $m^2$ to tens of $km^2$ will be gathered through field sampling in June-September 2000. Analysis of these samples will be conducted during the following 8 months, along with generation of data sets derived from on-ground surveys, published literature, and remote sensing to develop accompanying GIS layers. Combined with the results of the ongoing examination of the properties of various statistical approaches to spatial pattern and scaling, these will form the foundation for the initial stages of model development. The resulting models will be tested using field data gathered in summer 2001, followed by another phase of sample analysis and model refinement.

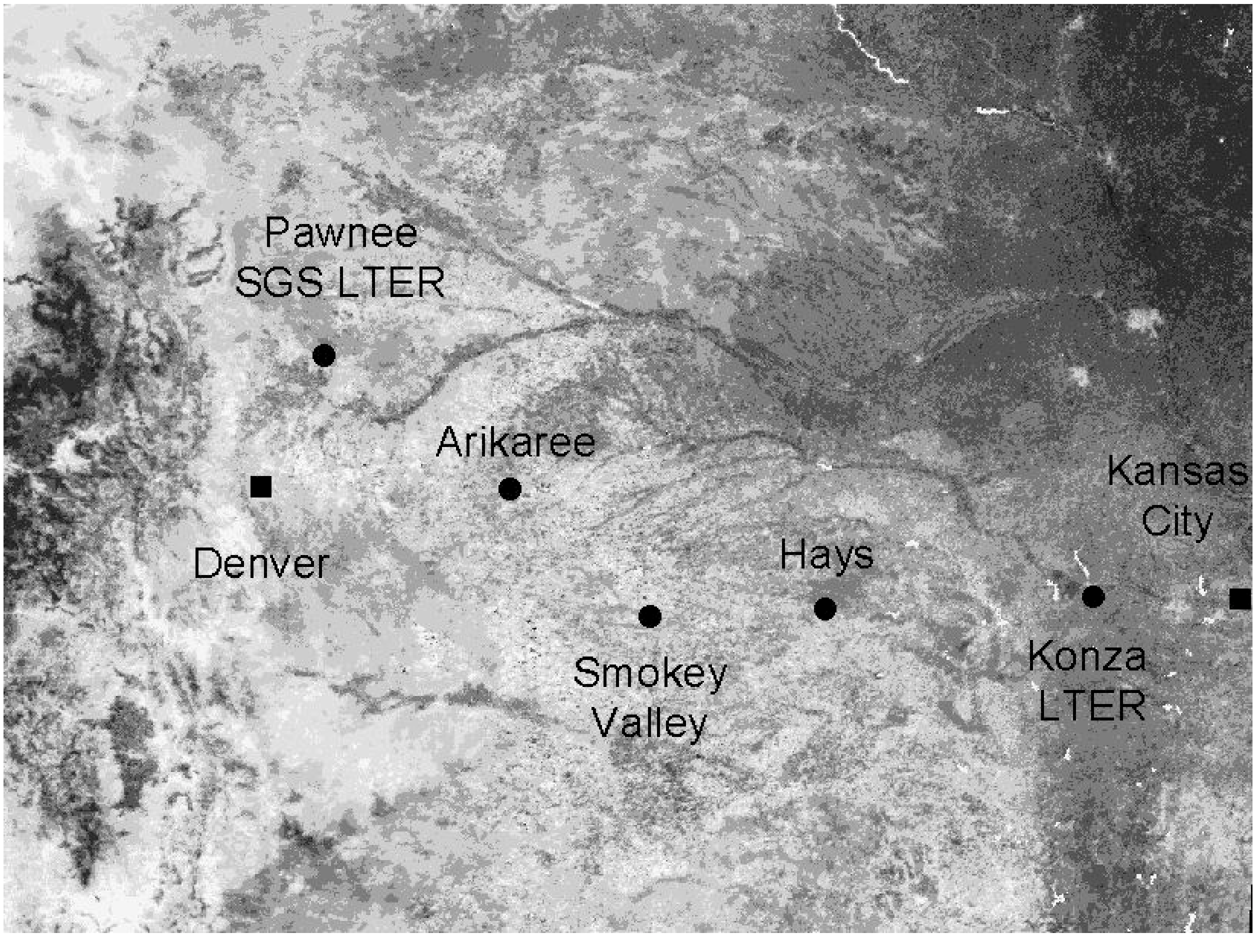


**Figure 1.** The Western Great Plains, showing the region encompassed by the scaling transect. LTER = long-term ecological research site. SGS = shortgrass steppe.

# Section 3.

## Projects Initiated With Fiscal Year 1999 Support

# Application of Remotely Sensed Data to Regional Analysis and Assessment of Stream Temperature in the Pacific Northwest

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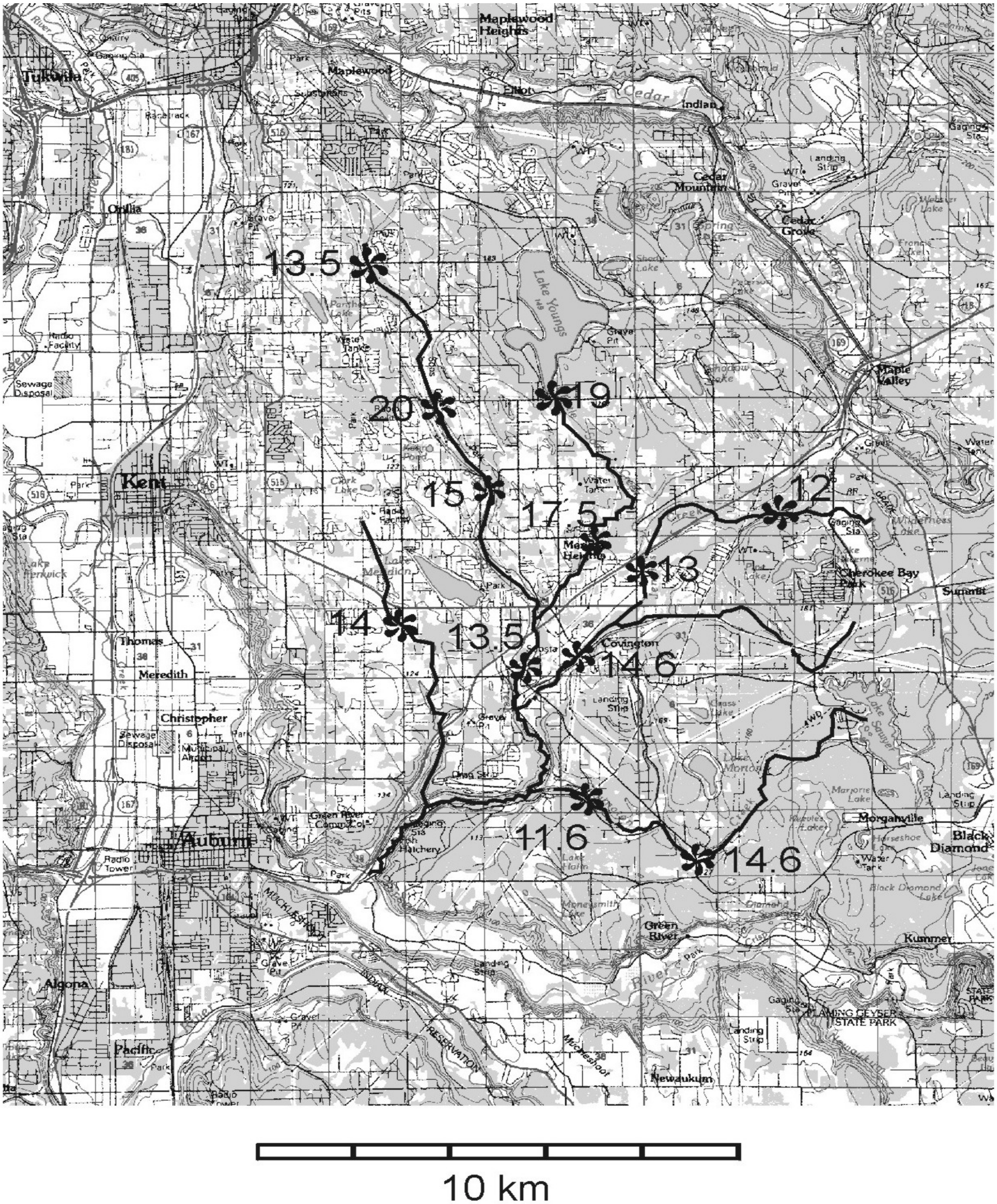
The characteristics of water vary throughout a stream network, presenting a major obstacle to regional water quality assessments. Figure 1 illustrates the variation in stream temperature observed on a single day in one stream network (covering approximately 100 km$^2$) in western Washington State. The goal of this project is to develop efficient methods for regional assessments of stream temperature using remotely sensed thermal infrared (TIR) images of stream corridors to augment in-stream temperature monitoring. The TIR images are obtained from the ASTER camera mounted on the Terra Satellite that was launched on December 18, 1999, as well as from a forward-looking TIR radiometer mounted on an aircraft.

The research is focused on water temperature to illustrate and explore methods of water quality assessment because water temperature is biologically important, it is affected by anthropogenic activities, and the kinetic temperature of visible surfaces can be measured over large areas using aircraft- and satellite-based instruments. A hierarchical approach is used in which temperature monitoring techniques are adapted to address the different issues faced in different parts of a stream network. The range is from large streams that are clearly visible from both remote platforms, but may not be thoroughly mixed, to small streams that constitute only a portion of any "pixel" in a remotely sensed image from the Terra Satellite.

Although the specific methods for monitoring stream temperature vary depending on location in a stream network, this approach takes advantage of the synergy between remotely-based and in-stream instruments as illustrated by four examples. First, remotely based instruments identify strong longitudinal (downstream) temperature gradients and the appropriate location and "density" of in-stream monitoring stations. Second, in-stream measurements quantify the spatial temperature structure of streams that is represented by single values (i.e., pixels) in remote images. Third, in-stream instruments provide a continuous time-series of temperature for periods when remotely sensed images are not available. Fourth, remotely based measurements facilitate interpolation of water temperatures between in-stream measurements.

Existing water quality monitoring programs provide a spatially limited view of conditions in stream networks. Synoptic surveys, such as those illustrated in Figure 1, expand the purview of a water quality monitoring program, but many gaps in the coverage remain. The target is to produce stream temperature maps that fill in the gaps and provide a more complete picture of water quality in the region.




Base map: USGS 1:100,000, Tacoma, WA

**Figure 1.** Mid-day stream temperatures (C) on August 19, 1998, throughout the Soos Creek Network, King County, WA.

# Effects of N Deposition on Gaseous N Loss From Temperate Forest Ecosystems

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Although much effort has gone into determining the fate of atmospheric N in temperate forest ecosystems, many uncertainties remain as to just where N is stored and what processes and pathways influence N retention and/or loss. One of the largest areas of uncertainty is gaseous loss. This flux may be large and may be very sensitive to N deposition.

The specific objectives of this research project are to: (1) determine the importance of gaseous loss of N from temperate forest ecosystems; (2) determine the impacts of N deposition on gaseous loss of N from these ecosystems; (3) test a mechanistic model that relates N gas emissions to N availability and soil moisture content; and (4) develop a new and more mechanistic version of the daily NASA-CASA ecosystem model for N gas emissions that can be applied at the regional level using satellite remote sensing and other spatial data sets in a Geographic Information System (GIS) format. This new simulation model will be used to assess trends in N cycling over gradients of N deposition in the northeast United States and to project changes in N gas fluxes with changing air pollution.

Gas fluxes (NO, $N_2O$, $N_2$) will be sampled on a monthly basis at five sites along an N deposition gradient in the northeast United States: Fernow Experimental Forest, WV; Catskills State Forest, NY; Hubbard Brook Experimental Forest, NH; Harvard Forest, MA; and Bear Brook Watershed, ME. Several additional measurements of factors known to control flux rates (e.g., N pool sizes and turnover rates, denitrification rates, soil temperature, soil pH, and soil moisture) will be made. Samples will be taken in both N fertilized and unfertilized plots at each location. These data then will be used to develop a new and more mechanistic version of the daily NASA-CASA ecosystem model for N gas emissions that can be applied across a 10-state region (ME, NH, VT, MA, RI, CT, NY, NJ, PA, and WV) using satellite remote sensing and other spatial data sets in a GIS format. This new simulation model will be used to assess trends in N cycling over gradients of N deposition in the northeast United States and to project changes in N gas fluxes with changing air pollution.

Field measurements for this project have not begun yet; however, one of the first tasks has been to establish experimental designs to capture the main factors influencing N gas fluxes at the different sites (e.g., topographic position, N availability, species composition). Preliminary data from one of the sites, the Hubbard Brook Experimental Forest, suggest that tree species composition may be a strong controller/indicator of N gas fluxes at these sites (see Figure 1).

One of the least well-understood facets of the complex N cycle is loss of N in gaseous forms from the soil. Quantifying this flux is important from the perspective of understanding the fate of N deposited on these ecosystems from the atmosphere and for determining the source strength of northeastern forests in regional and global budgets of NO (an ozone precursor) and $N_2O$ (a greenhouse gas). The modeling effort will permit placing constraints on the regional contribution of the soil source of N gases and make projections of the impact of increasing N saturation on the regional atmospheric budget of these gases. Regional quantification of gaseous N loss and improved understanding of the spatial variability of this process will be important for development of critical load tolerances for N deposition.

Sites currently are being established, instruments are being purchased and set up, and field and laboratory protocols are being finalized. Flux measurements should begin by early June 2000.

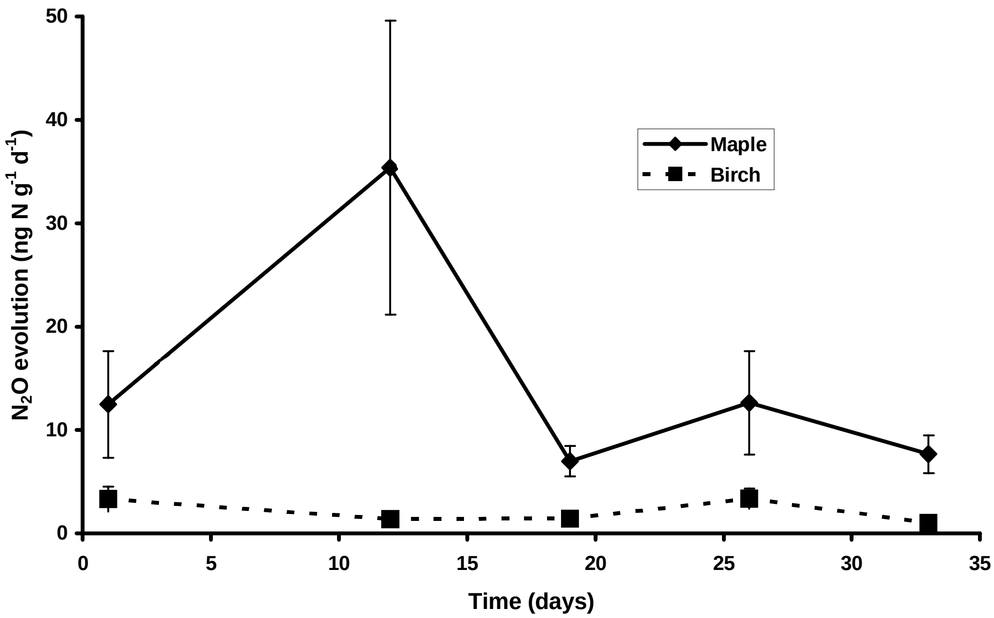


**Figure 1.** $N_2O$ production in soils from sugar maple and yellow birch stands at the Hubbard Brook Experimental Forest, NH. Soils were incubated in the laboratory for 33 days. All differences between points were statistically significant at $p < 0.05$.

## Regional Analysis of Net Ecosystem Productivity of Pacific Northwest Forests: Scaling Methods, Validation, and Results Across Major Forest Types and Age Classes

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This project started on July 1, 2000. The objectives are to: (1) develop and test a regional scale approach that combines modeling, data from remote sensing, sample surveys, and intensive research sites to better estimate variation in the carbon balance of forest ecosystems in the Pacific Northwest; and (2) apply this strategy to investigate how processes controlling variation in net ecosystem productivity are influenced by forest development, disturbances, and contrasting climatic conditions.

Net ecosystem productivity (NEP) is a critical characteristic of terrestrial ecosystem response to environment. Processes controlling NEP operate on a variety of temporal and spatial scales and are influenced by plant physiology, forest age or developmental stage, climate, and disturbance. This project will simulate productivity and NEP in Oregon and Washington using a combination of remote sensing, survey data, process-level measurements in different age classes of forests, and process models. Model outputs will be tested using detailed ecosystem studies at intensive sites, more basic ecological measurements at other existing intensive sites, and survey data from Forest Health Monitoring (FHM) and Forest Inventory and Analysis (FIA) plots.

For each 30 x 30 m unit of ground, forest productivity will be predicted and evaluated for an east-west longitudinal swath along a steep climatic gradient through central Oregon from the coast to the semi-arid east side of the Cascade Mountains, and a north-south latitudinal swath from the southern Oregon border to southern Washington. BIOME-BGC, a physiologically based process model, will generate current NEP, productivity, and "carbon stress index" estimates for the region for a mean climate year, 1999, and 2000. STANDCARB, an ecosystem process model, will be used to estimate current carbon pools by accounting for long-term trends in NEP. BIOME-BGC will be initialized using remote sensing (Thematic Mapper) estimates of forest cover type, age class and the amount of leaf area present for photosynthesis, and soil survey data. The model will be driven by spatially distributed climate data based on interpolations of weather station data by climate models. Remotely sensed variables will be validated with data from intensive sites and the survey sites, and new measurements in underrepresented forests.

Model predictions of carbon budget components will be validated with flux data, other intensive site data, and survey data. Sensitivity of NEP to forest type, developmental stage, disturbance, and interannual variability in climate will be evaluated. A practical approach for linking remote sensing, sample surveys, and intensive site data via modeling at the regional scale will be demonstrated.

The data acquisition phase will start soon, so there are no findings to report as of yet. In the first year of this project, existing data will be assembled, remote sensing imagery will be acquired, and the spatially derived climate data sets will be produced. Working with statisticians, a sample design for the field measurements will be developed. The field season will begin in June 2001. Modeling activities will include testing the models with existing site data across the region.

# Multiscale Effects of Forest Fragmentation and Landscape Context on Population Health of Birds

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Data from intensive studies of avian demography at replicated sites and multiple spatial scales within and among geographic regions will be used to assess the effects of spatial scale and landscape context on major factors (nest predation and Brown-headed Cowbird parasitism) that influence the health of bird populations.

Results from this work will provide new and more general insight into the influence of spatial scale on fragmentation and landscape context in relation to nest predation and cowbird parasitism in birds. Moreover, results of this work then can be applied to land cover data across North America and across time to examine and predict the potential demographic consequences of future land-use changes on bird populations.

A Geographic Information System (GIS) will be used to characterize landscapes, particularly in terms of forest fragmentation, at roughly 30 sites across the United States using bird demographic data compiled for the Breeding BIology Research and Monitoring Database (BBIRD) program. At these sites and the more than 250 plots within them, data on nesting success have been collected from more than 30,000 nests of more than 200 species of birds.

The BBIRD and GIS data will be used to examine: (1) the spatial scales that influence demographic processes (i.e., predation and parasitism) within and among geographic regions; (2) the role of cover type (e.g., forest, agriculture, human habitations, etc.) in the landscape (landscape context) on predation and parasitism relationships; and (3) predation and parasitism relationships with landscape characteristics among regions.

The information on predation and parasitism relationships obtained from these three sets of analyses will be used to: (1) develop predictive models of bird demographic responses to forest fragmentation throughout North America; (2) examine the demographic consequences among functional groups (i.e., nest types, habitat requirements) to determine variation in population sensitivity and identify high-risk species and species groups; and (3) model these demographic relationships in terms of population sustainability to attempt to identify landscape conditions that support source (self-sustaining) populations.

At this time, efforts are focused on building the necessary GIS databases for characterizing landscapes. GIS data are being compiled on a site-by-site basis; each site's landscape is defined by a circle with a 100 km radius centered on that site. The National Land Cover Data set (NLCD) provides a consistent layer for the conterminous United States at a spatial resolution of 30 m. Other GIS layers include digital elevation data, hydrography, roads, and the locations of the BBIRD sites. Once the databases are assembled, predation and parasitism will be examined, then modeling can begin.

# Regional Ecological Resource Assessment of the Rio Grande Riparian Corridor: A Multidisciplinary Approach To Understanding Anthropogenic Effects on Riparian Communities in Semi-Arid Environments

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Riparian ecosystems of the southwestern United States are characterized by high species diversity and are among the most productive ecosystems of North America. The rapid decline of riparian ecosystems throughout the United States has made riparian conservation a focal issue for the public, federal and state governments, and private organizations.

Among the objectives of this 3-year multidisciplinary study of the riparian corridor are to: (1) acquire and analyze high-resolution remotely sensed data from multiple sensors; (2) integrate existing and new field data and remotely sensed data into a Geographic Information System (GIS); (3) ascertain whether the native communities are maintaining themselves and identify the topographic, edaphic, and other ecological factors that perpetuate these communities; (4) interpret spatial variations in riparian habitats, including comparisons of the north and south banks of the Rio Grande; (5) analyze temporal changes at specific locations; and (6) develop a foundation for future analysis of riparian floodplain communities by linking local and remotely sensed regional data using GIS.

The study area includes the lower reach of the Rio Grande from Falcon Dam to the mouth of the river (see Figure 1). Detailed, local-scale, ecological transects of dominant riparian vegetation will be correlated with high-resolution videography and multispectral data to delineate the spatial extent of the riparian community. This correlation will provide ground truth for the classification output from high-resolution (4–7 m) hyperspectral and airborne synthetic aperture radar (SAR) data. Classification output from high-resolution data will in turn provide the class mixtures for medium-resolution (20–30 m) Landsat™ and SPOT multispectral data that cover the entire study area, on both sides of the Rio Grande. Data on geology, soils, land use, water quality and hydrology, and topography from Topographic Synthetic Aperture Radar (TOPSAR), as well as airborne laser altimetry data acquired for the study, will be investigated as additional inputs to the classification process and will be used to help explain temporal and spatial changes in ecological resources indicated in the remotely sensed data. GIS-based spatial models and statistical modeling results will be used to predict the expected future effects of landscape change on plant distribution, biodiversity, and functional organization at multiple scales of resolution. The developed methodologies will help to guide future assessments of riparian regions.

Only very preliminary analyses of data have been completed as of April 2000. Initial integration of data into a GIS and preliminary analysis reveal the utility of certain data sets. For example, U.S. soil maps include parameters such as conductivity or soil salinity, which allow construction of specific GIS layers that can be used to examine relationships with riparian vegetation. One difficulty has been correlating Mexican soil maps with U.S. soil maps because of differences in scale and terminology. Preliminary analysis of two airborne hyperspectral data-imaging systems, which have similar spatial resolution but different spectral coverage, shows that riparian vegetation composition is better defined by the sensor that includes longer wavelength infrared bands.

The next steps are to continue acquiring needed data, classifying remotely sensed data, ground truthing, and to begin preliminary analysis and testing of the methodology.

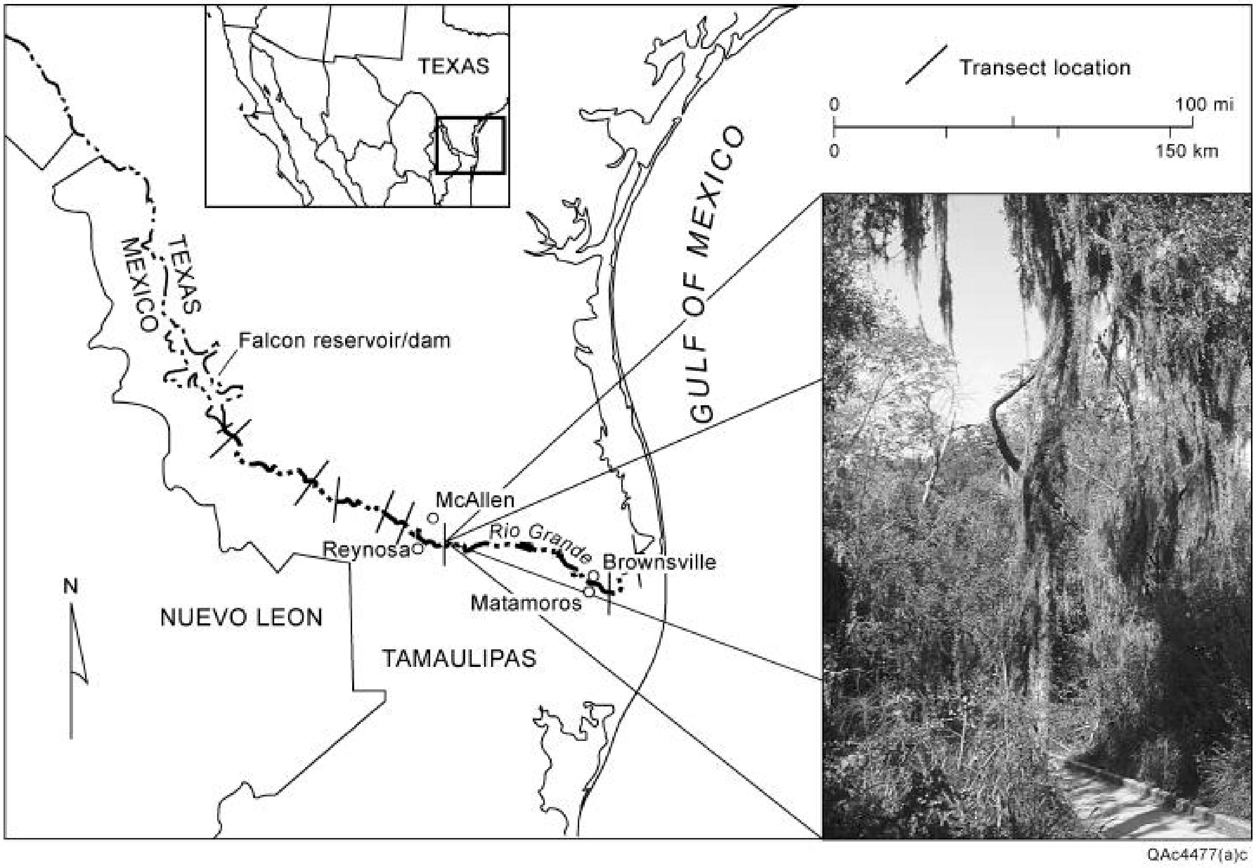


**Figure 1.** Map of Lower Rio Grande valley showing approximate location of existing ecological transects and example of riparian vegetation in the Santa Ana National Wildlife Refuge.

# A Hierarchical Patch Dynamics Approach to Regional Modeling and Scaling

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Scaling is imperative for understanding and predicting broad-scale dynamics based on fine-scale observations. To scale up or down, it is necessary to construct multiscale models or to link individual models at different scales, which together capture the spatial heterogeneity of pattern and process. Hence, to develop cross-scale models, there are both theoretical and technical challenges.

To meet these challenges, a hierarchical patch dynamics modeling (HPDM) approach is proposed (see Figure 1). HPDM involves three basic steps. First, based on empirical data, the patch hierarchies relevant to the phenomena and objectives of study using the principles of loose vertical and horizontal coupling and near-decomposability need to be identified. The second step is to develop and validate unit hierarchical models in which the next higher level provides boundary conditions and other constraints, while dynamics at the next lower level are described mechanistically. The third step is to link unit hierarchical models across scales through an input-output chain.

The HPDM approach will be discussed and illustrated through an example of modeling the pattern and process of urbanization in the Phoenix metropolitan area.

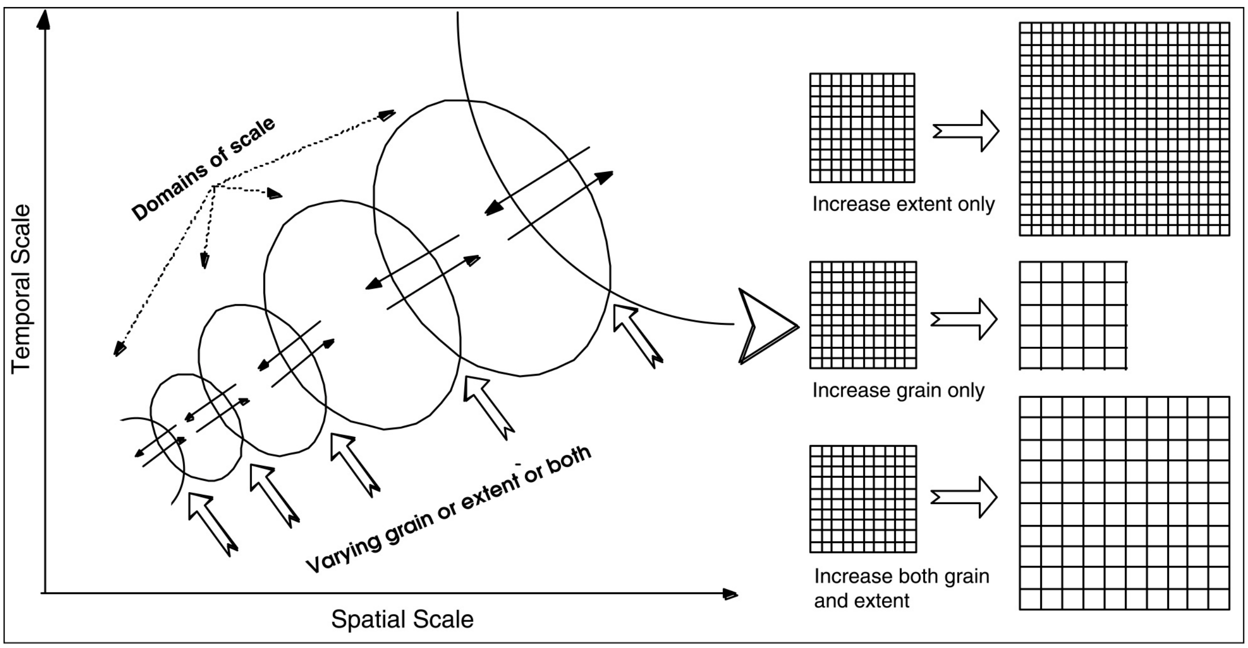


**Figure 1.** Hierarchical scaling or extrapolating information along a hierarchical scaling ladder. Scaling up or down is implemented by changing model grain size, extent, or both across successive domains of scale.

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